Grazing Optical Polishing: a Fast and Efficient Technique for Making Lightweight Sub-Arc-Second X-ray Mirrors

Completed Technology Project (2014 - 2016)

Project Introduction

Future x-ray telescopes, including the proposed WFXT, Generation-X, and SMART-X missions, measured in terms of angular resolution, energy resolution, and photon collection areas, must be significantly more powerful than the four currently in operation: Chandra, XMM-Newton, Suzaku, and NuSTAR. Given constraints imposed by existing launch vehicles and budgets likely to be austere, future missions can only be realized if a new technique is developed that can fabricate high angular resolution (sub-arc-second) and lightweight x-ray mirrors (areal density less than 1 kg/m2) at low cost (less than $105 per square meter of mirror area). Existing x-ray mirror fabrication technologies can be broadly classified into two categories: polishing and replication. Polishing is expensive and slow, producing high angular resolution mirrors that are heavy, like those in the Chandra telescope. Replication is inexpensive and fast, producing mirrors that are lightweight but have low angular resolution, like those in the Suzaku telescopes. The future of x-ray astronomy calls for a mirror fabrication process that can simultaneously achieve high angular resolution, light weight, and low cost. We propose a new mirror fabrication process, called grazing optical polishing (GOP), designed to polish grazing incidence optics using shear or grazing force. It is based on polishing and therefore can achieve sub-arc-second angular resolution. It takes advantage of the nearly conical nature of x-ray mirrors to achieve a high polishing rate, minimizing fabrication cost and time. Combined with the use of single crystal silicon as the mirror material, this process can achieve unprecedentedly lightweight and accurate mirrors. (See Table 4 for a succinct description of the entire fabrication process.) At the end of this three-year effort, we expect to be able to make high resolution and lightweight x-ray mirrors that, when properly integrated into mirror modules, are capable of forming sub-arc-second x-ray images. The existence and availability of these mirrors will stimulate competition and collaboration in our community to develop corresponding alignment and integration techniques. The combination of the excellent mirrors and an integration process, together with good detector technology, will extend the current golden age of x-ray astronomy and advance it into the 2020's and beyond.

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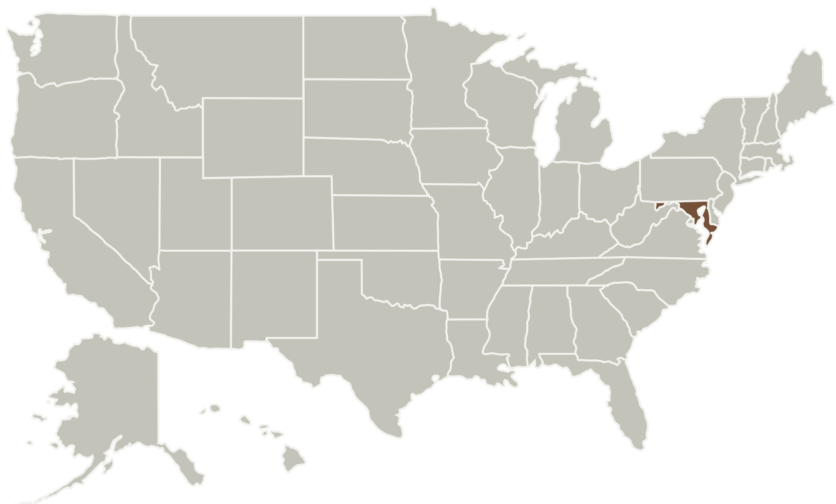
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations
Maryland

Project Management

Program Director:
Michael A Garcia

Program Manager:
Dominic J Benford

Principal Investigator:
William W Zhang

Co-Investigator:
Raul E Riveros

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.2 Observatories
    └ TX08.2.1 Mirror Systems

Target Destination
Outside the Solar System